

Learning Experiences and Misconceptions of Vision

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by

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### ***Abstract***

This research studied a misconception held by many college students, namely, the belief that emissions from the eyes occur when see, which was consistent with the extramission theory of perception held by some early Greek philosophers (Gregg et al., 2001). The present study was designed to measure if different readings about vision in combination with the use of pretests could overcome participants' misconception of extramission beliefs. Two hundred and thirty-one college students participated in the study and were randomly assigned into one of the eight conditions. Half of the participants were given an extramission pretest and the other half were not. All of them were given either one of the three experimental readings or the control reading following by an extramission posttest. The experimental readings included basic information about vision. Along with the experimental readings were interventions I predicted could reduce misconceptions. Participants in all experimental (total of six) conditions showed improvement in performance compared to those in the control group. That is, the presence of a pretest in combination with a vision reading in general improved performance. This finding on the impact of the readings was surprising and was rarely observed in published studies.

### *Learning experiences and beliefs about vision*

Numerous studies have been conducted both in the fields of psychology and education about how people form their general and scientific beliefs. People often have a previous understanding on a topic before being educated on it. Studies have shown, however, that even after education on the topic, people's misconceptions still persist.

One misconception in science, the topic of this thesis, is called the extramission theory of vision. This misconception contends that something (e.g. images, rays) goes out of the eyes during the visual process. The belief about visual extramissions has a long history that can be traced back to the ancient Greek philosophers such as Plato, Euclid and Ptolemy (although Aristotle believed in intromission, which was the correct view of visual processing) (Meyering, 1989). Many college students believe in visual extramission, though. For example, it was reported that over thirty percent of adults studied believed in the extramission theory of vision, while about twenty five believed in the hybrid of the intromission and extramission theory (Winer, Cottrell, Karefilaki, & Gregg, 1996). Results were surprising due to the fact that many college students have had education on basic biology or physiology.

There are other types of misconception. The idea that the earth is flat seemed to be a common belief that exists among children (Vosniadou & Brewer, 1992). They interpreted the finding and explained that children formed their belief about the earth having edges through their everyday experiences. They named it the mental model of the earth. Moreover, they believed that children would modify their model by acquiring new information and by gradually shaping their model to be consistent with a model that was better accepted among the society (Vosniadou & Brewer, 1992).

An unpublished study by Cottrell and Winer (2005) has also shown that people seem to have misconceptions the location of emotions. Some people believed that love and sadness are located in our heart, rather than in the brain. Such misconceptions should not be surprising, since different cultures have expressions or practice that could easily mislead our beliefs. Phrases such as “broken heart” are good examples of how the English speaking culture portrays the link between emotion and the wrong organ, our heart. However, such a phenomenon is not limited to the English speaking culture. Many Chinese characters referring to emotions have the component of a “heart”.

Many studies have addressed the topic of how misconceptions are formed. Consensus was reached among the field that children often form their misconceptions through everyday physical contact with the outside world (Guzzetti, Synder, Glass, & Gamas, 1993). Daily experiences could often be wrongfully interpreted and become concrete. While misconceptions are often observed in children, college level students also seem to share some of the same erroneous ideas (Guzzetti, Williams, Skeels, & Wu, 1997). People may also form a model or schema in their mind, and they may refuse to accept new counter-factual information.

The misconception about vision could be related to the American popular culture. Many American children grow up watching and reading cartoons and comic books. These sources of information contain misleading messages about visual perception and might have contributed to the misconception. The cartoon character Superman is no stranger to most Americans. In fact, he might be the idol for many Americans growing up at the seventies. Superman has the special ability to attack enemies with emissions from his eye. The rays

were so strong, they could even cut through steels. It is natural to speculate that the “Superman phenomenon” could have contributed to the myth about the mechanism of human eyes.

Another reason why people might hold such a misconception could be the fact that many vertebrates (for example, cats, crocodiles and raccoons) have tapetum lucidum, a reflective layer behind or within the retina of the eye. This layer reflects light back into the retina and aids vision in the dark among many animals that usually hunt at night such as cats (Ali & Klyne, 1985). Many people driving at night have seen a raccoon on the road with eyes that resemble a light bulb. Such experiences may contribute to the misconception that humans, a species that does not have tapetums, rely on emissions from their eyes in order to see.

No matter what kind of misconception people hold, many studies have discovered that they are extremely difficult to alter, and common educational approaches (e.g. textbook passages, lecturing) seem to be unsuccessful in altering misconception (Brown 1992; Champagne, Gunstone & Klopfer, 1983). For example, researchers tried to present participants with refutation that countered participants’ misconception (e.g. the earth is a sphere), but they were unsuccessful. The position of a refutational statement in a paragraph also makes no difference in changing students’ alternative ideas (Maria & MacGinitie, 1987).

Guzzetti et al. (1993) summarized seven strategies commonly used to overcome scientific misconceptions using a careful meta-analysis. These seven strategies involved using: refutational text, non-refutational text, activation activities, think sheet, discussion strategies, and other text-based activities and traditional instructions. They found that a combination of activation activity and refutational text was an effective way of reducing

misconceptions. Refutation here refers to text material that directly refutes the misconception. Activation activities serve to bring up correct knowledge is contrary to the misconception. Another effective text-based strategy was to create dissatisfaction in participants' current understanding followed by the introduction of the correct knowledge. However, results showed that activation strategies used alone were not effective at altering misconceptions.

Guzzetti et al. (1993) also concluded that the learning cycle first created by Lawson (1958), including three steps: exploration, term introduction and concept application, was effective at reducing misconceptions. Giving little information in the exploration stage, assigning non-refutational text in the introductory stage and asking participants to apply the theory in some way were effective at altering misconceptions.

Studies have also found that traditional college-level education was unsuccessful at improving participants' understanding of vision (Gregg, Winer, Cottrell, Hedman, & Fournier, 2001). They reported that results from multiple experiments showed that the extramission beliefs about vision were robust and persisted even after contrary information was provided to participants. These investigators also speculated that the reason participants failed to improve their understanding of vision was that the material was complicated and no direct refutation about the extramission theory of perception was involved.

Gregg et al. (1993) then simplified the material to a great extent and added a condition in which they directly refuted the extramission theory. Here, they specifically informed participants that nothing left the eye during the act of seeing. Results showed an impressive short-term effect for college students. However, the effect disappeared on retesting after a

period of three to five months. At that time, performance for participants in the experimental conditions was not different from that of the control group. This finding once again, confirmed that the misconception about visual processing was robust and immune from traditional educational interventions.

The purpose of the present study is to find out whether different learning materials could improve college students' understandings about vision. It was hypothesized that that participant would have more correct answers on a test about visual extramissions if they were assigned to experimental conditions requiring a comparison of readings about the nature of vision with tests about extramission.

The present study had two major variables. In one, approximately half the students were tested with a pretest–reading–posttest design while the other group was tested under a reading–posttest only design. Thus one group was tested with repeated-measures design, in which pre and posttests were administered, while the second group received posttests only.

Within each of these two groups, there were four reading conditions. In one experimental condition participants received only the vision reading, that is a reading explaining the process of vision, with no further instructions. In two other experimental conditions, the same reading was given with different instructions, designed either to require a direct comparison between the reading and the tests or an activation of the information in the reading, i.e., thinking about the reading. . An additional control condition presented a reading about the psychologist, John Watson, without any mention of the process of vision.

In sum, the experiment had a 2 X 4 design: the presence or absence of pretests given with one of 4 experimental or control readings. I hypothesized that the experimental conditions

would be effective only when pretests were given. Moreover, I hypothesized that although all these experimental conditions would improve performance, the reading comparison condition would yield the highest scores, the activation condition slightly lower scores, and the reading only condition, the lowest scores of the experimental groups.

### ***Method***

#### ***Participants***

Two hundred and twenty eight students from an introductory psychology course participated in the study, including 73 males and 155 females. Participants received partial credit in return.

#### ***Tests and Procedure***

Participants were randomly assigned to experimental and control conditions. All experimental readings contained a paragraph about vision, while control subjects received an irrelevant reading about John Watson the psychologist (the exact appears in Appendix 3). The possibility of the improvement simply due to reading was ruled out by giving the control reading. The reading on vision described the mechanism of vision and anatomy of the eyes, and it was designed to help students have better understanding about the visual process. Participants were asked to notify the experimenter when they were finished with the reading. Readings were put away after completion and before the administration of the posttest. All the participants were administered the eight-question posttest after the completion of the reading. The pretest was exactly the same as the posttest. Participants were debriefed after experiments, the exact debriefing appears in Appendix 4.



### ***Test Materials***

Eight-question tests were used to assess participants' knowledge of visual perception. For those participants receiving pre- and posttests, the same test was repeated.

The eight test questions asked participants whether they believed emissions from eyes accompany vision. On seven of the eight questions, participants were read the questions and shown animated graphics on a computer screen. The animated graphics gave representations of each of the choices given in each question. Thus, the first question asked whether anything like rays, waves or energy comes into or goes out of the eyes with one graphic showing visual input and another showing visual output. On each graphic representation the profile of a unisex person was oriented toward and presumably looking at a block. Visual input and output were depicted by lines moving toward or away from the eyes. These two choices of input and output only were presented on all additional questions.

The next six questions added one or two more representations of combinations of intromission and extramission: input followed by output; output followed by input, simultaneous input and output. The exact questions in the order of their presentation appear in Appendix 1. The computer program allowed a maximum of four simultaneous representations of vision. A final eighth question was presented verbally, i.e., without computer graphics, and presented all five possible choices.

The questions and choices were read to the participants. The wording of the questions was the same for all eight items, that is, 'what do you think happens when we see? Does anything like rays, waves or energy come into or go out of the eye?'

The set of test questions always began with the two-choice item, which asked

participants to choose between intromission and the extramission. The questions then proceeded to 3 and 4 choice items, ending with the final purely verbal 5 choice item.

At the end of testing, participants were asked 4 more questions, on whether they had prior knowledge about the content of the experiment and whether they were educated on the extramission theory of perception in their introductory psychology classes.

### ***Conditions***

As noted, in combination with the three experimental and single control reading conditions, half the participants were given a pretest while the other half were not. This yielded a 2 (pretest vs. posttest only) X 4 (three experimental readings and one control reading) condition study.

Reading Only Condition. In the reading only condition participants received a reading on vision, adapted from an introductory psychology text, with no instructions except to read the text. The reading described the eye and the process of vision, and referred to visual input. The exact reading appears in Appendix 2. No mention was made of extramission.

Reading Comparison Conditions. The reading comparison conditions differed depending on whether participants were in the pretest-posttest vs. only posttest conditions although in both instances a comparison between material contained in the text and answers to the questions on vision was requested. Thus when a pretest was given, participants were asked to compare the answers that they had given on the pretest with the information in the subsequent reading. Specifically, they were asked: “I want you to think back about the questions you answered about vision. Did the answers you gave to the questions about how we see agree completely with the explanation of vision that you just read? Think before you

answer this question. Did your answers to the question on seeing agree completely with the explanation of vision that you just read?"

When only posttests were given, participants were expressly instructed to compare the text they just had just read with the responses they would give to the questions they were about to receive: "Before you answer each question think back to what you read and think whether the answer you are about to give to the question agrees completely with the explanation of vision that you just read. Remember, before you answer each question ask yourself whether your answer will agree completely with the explanation of vision that you just read."

Reading activation Condition. The reading activation instructions were the same in the groups with and without pretests. The idea of these instructions was to ask participants to think about the readings, without requesting a direction comparison between readings and responses to the vision questions. The wording was as follows: "I want you to think back about the reading. Do you remember what the reading was about? ... Tell me what the reading was about."

The reading activation conditions served as a control for the reading comparison condition. That is, it is possible that the reading comparison condition might have produced a gain, but not because a comparison was requested. Instead, an improvement might have occurred merely because participants were asked to access the material in the reading.

An outline of the 8 conditions appears in Table 1, which presents the sequences of various tests and readings. In this table a T stands for the vision test, which was given before or after readings. Various reading conditions were designated: (A) W for the Watson

control reading; (B) R for reading only, that is reading with no additional instruction; (C) Ra for reading activation; and (D) Rc for reading comparison. Thus the expression TWT in the Table indicates the following sequence: Pretest, Watson Reading, and Posttest.

Table 1.

	←	Reading Conditions		→
	Control Reading (Watson Reading)	Vision Reading (Without instructions)	Vision Reading with Comparison	Vision Reading with Activation
Pre-Posttest Conditions ↓				
Pretest-Reading-Posttest	T W T	T R T	T Rc T	T Ra T
Reading-Posttest	W T	R T	Rc T	Ra T

T=Pre or Posttest

R=Vision Reading

Rc=Reading Comparison

Ra= Reading Activation

W=Watson Reading

### *Results*

Participants were given a score of 1 if they gave a pure intromission answer to any one of the eight test questions. Participants who answered any other responses (e.g. extramission or a combination of intromission and extramission) to any one of the eight questions were given a 0. Thus, the highest score that participants could have possibly achieved was 8 (7 points for the computer questions and 1 point for the purely verbal question.) The lowest score was 0, which meant all wrong answers were given to the eight-question test. The total score of the pretests, the total score of the posttest and the total score of the combined pre- and posttests were used as dependent variables.

Data for participants who reported having been taught about the extramission theory of perception in their introductory psychology classes were excluded.

An initial analysis was conducted on the pretest scores (for subjects who received a pretest). In this analysis (and in all subsequent analyses) the scores were the number of correct answers given to the questions (range from 0-8). An analysis of variance (ANOVA) showed that there were no differences between the scores due to conditions,  $F(3, 113) = 1.89$ ,  $p = 0.137$ . This finding helps with the interpretation of the results since it suggested that participants in different conditions started with similar beliefs about vision.

It is interesting that a large number of students had at least one error on the 8-question vision tests. In fact, on the pretests only 42 of 114 participants (37%) had perfect scores. Moreover, 47 participants (41%) had fewer than 3 questions correct! An improvement in posttest scores were observed after readings was given and will be described. What is of interest, though, is the large number of people who erred: one hundred and twenty eight out of 228 participants (61%) had perfect scores, while 68 out of 228 participants (30%) had fewer than 3 questions correct after the reading education was given.

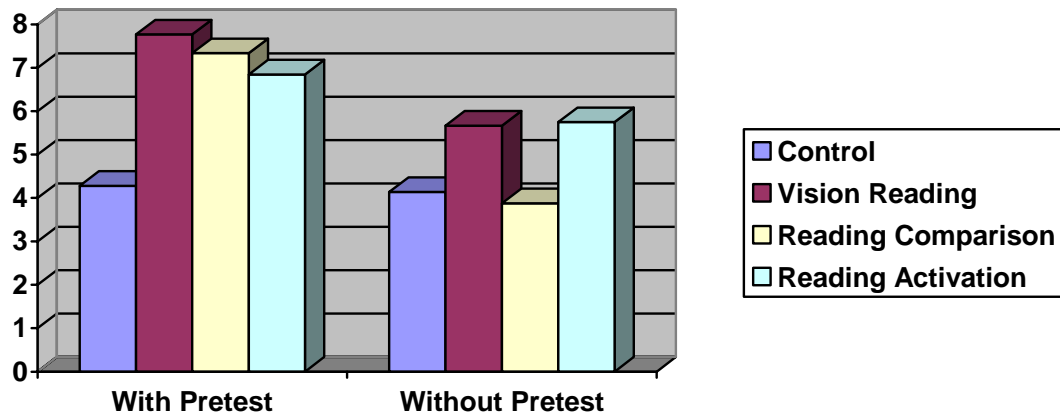
Next I conducted a 2 (with and without pretests) X 2 (Sex) X 4 (Reading Conditions) ANOVA on the number of correct posttest scores. The interaction approached significance ( $p = .055$ ). However, I examined for the effects of the different experimental conditions as a function of having or not having a pretest, since I predicted there would be an interaction.

The analysis showed that when pretests were given, posttest scores in all experimental conditions ( $M=7.77$ ,  $SE=0.576$  for *reading only*;  $M=7.34$ ,  $SE=0.604$  for *reading comparison*;  $M=6.85$ ,  $SE=0.594$  for *reading activation*) were significantly higher than posttest scores in the control condition with  $M=4.28$   $SE=0.672$ . (All means in this and in other analyses were Least Square Means and comparison between means was through LS means tests.) In

other words, when pretests were present, participants in all conditions that involved one of the three experimental readings scored significantly higher than participants in the control condition on their posttests. However, when pretests were not given, participants in the control and experimental groups did not score differently. That is, when pretests were absent, participants in the control condition scored an average of  $M=4.14$ ,  $SE=0.576$  comparing to  $M=5.67$ ,  $SE=0.630$  for *reading only*;  $M=3.88$ ,  $SE=0.615$  for *reading comparison*;  $M=5.75$ ,  $SE=0.622$  for *reading activation*. It is interesting, though, that the differences between the control condition and reading activation approached significance ( $p=0.059$ ).

The comparisons among posttest scores of all conditions are represented in the Graph 1 below.

**Comparisons among posttest scores in all conditions**



Graph 1

An additional repeated measures analysis on the scores of participants receiving both pre and posttests confirms the conclusion that all the experimental groups were different from the control. The overall difference between pre and posttest scores was significant,  $F(1,$

199) = 28.67,  $p < .0001$ . Moreover, the condition by pretest-posttest comparison was not statistically significant,  $F(3, 199) = 2.03$ ,  $p < .12$ . However, individual comparisons showed that participants in all three experimental groups had significant gains, while participants in the control group did not.

### *Discussion*

The results of this study show that a large number of college students believed in visual extramissions. The finding was consistent with published studies about scientific misconceptions (Gregg, Winer, Cottrell, Hedman, & Fournier, 2001).

Recall that I have hypothesized that the experimental conditions would be different from the control condition only when pretests were given. This hypothesis was generally substantiated. When there were pretests, each experimental group outperformed the control. And when there were no pretests, there was no difference between the control and the three experimental groups.

However, I also hypothesized that although all these experimental conditions would improve performance, the reading comparison condition would yield the highest scores, the activation condition slightly lower scores, and the reading only condition, the lowest scores of the experimental groups. This hypothesis was not supported. Instead all experimental groups seemed to be about the same.

Unlike the previous training studies on extramission, the present study combined training conditions with a pretest-posttest design. The presence of the pretests, in combination with the training seemed critical. An important implication of the present study is the significance of giving pretests when testing the impact of learning on overcoming



scientific misconceptions.

Why did the combination of pretests and experimental conditions prove to be effective? The improvement possibly occurred because the participants' misconceptions became evident to them when presented with the readings. Presumably, they automatically compared their misconceptions with the subsequent information about vision presented in the *vision reading*. No additional warnings (i.e. *reading with comparison or activation*) were needed to help them overcome their misconceptions.

An interesting finding was that some participants who claimed reading the intromission theory in the vision reading ended up giving answers other than intromission only to the test. One would assume that participants who recalled reading the intromission theory would immediately know that the extramission answers were incorrect. However, results showed a different picture. The question that arises is why did that occur? There are a few possible reasons.

First of all, the computer imaging could have been incomprehensible to some participants. Since researchers were not required to stop and check if participants were confused about the animated graphics, which could have been a problem under our radar. The computer animated graphics used lines to represent light rays going into or out of a human eye. Secondly, another explanation could be that students did not understand the relationship between light and vision. Thirdly, it is possible that participants did not take the experiment seriously. Some participants could have given wrong answers in contrary with their belief about vision. They could have been bored by the simple repetitive extramission answers. It is also possible that some might think that it was unnecessary to take visual questions

seriously. This action has long been an issue in self-report style studies. As much as it is a concern for researchers, it is also hard to prevent or detect. Results from the present study could be helpful for the field of science education. Students might be better able to overcome their scientific misconceptions if they become more aware of their wrongful beliefs before the correct information is given. Requiring students to engage in specific activation activities does not improve performance. The effects of pretests could be studied on other misconceptions in science.

However, it is possible that the immediate improvement in the understanding of vision following training could be attributed to the questions being identical on both the pretests and posttests. In another word, it was possible that instead of improvement of understanding about vision in general, the improvement could be limited to the better understanding the questions on the pretests and posttests. Ways to eliminate this possibility may include choosing different questions from a pool of questions that involved the extramission theory of vision for the pretests and posttests, and observe if improvement would still be present.

Nonetheless, the results might lead us to reconsider how trustworthy current education practices are. Many college courses taught nowadays still use the same process. Students are given the knowledge in class often without being challenged about their former misconceptions. Studies have shown that this is an inefficient way of learning. The present studies showed us that to learn what is right, it is better for us to know what is not right first.

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Unpublished studies by Cottrell and Winer (2004) show that many participants believe that they could feel when they were being stared at, which also suggested beliefs in emission from the eyes during the visual process.